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EG&G ROCKY FLATS

EG&G ROCKY FLATS, INC.
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November 30, 1993

93-RF-14529

ADMIN RECORD

Martin H. McBride
Assistant Manager for Transition
and Environmental Restoration
DOE, RFO

RESPONSES TO ENVIRONMENTAL PROTECTION AGENCY (EPA) AND COLORADO DEPARTMENT OF HEALTH (CDH) COMMENTS AGAINST STATISTICS STRAWMAN – NMH-606-93

Attached please find responses to comments made by EPA and CDH against the strawman that EG&G Rocky Flats and the Department of Energy, Rocky Flats Office distributed at our meeting September 29, 1993. These responses are similar to those contained in an earlier letter dated November 18, 1993 (NMH-598-93) but modified per your comments from the November 23, 1993 meeting with Steven Needler. The modified strawman gives the methodology which will be used on subsequent site-to-background comparisons.

Attachment A contains the responses to EPA and Attachment B contains the responses to CDH. The revised strawman is also attached (C). If you have questions or comments, please contact Steven Needler at extension 6961.

Ned M. Hutchins, Acting
Associate General Manager
Environmental Restoration Management

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Orig. and 1 cc – M. H. McBride

Attachments:
As Stated (3)

cc:
A. H. Pauole – DOE, RFO
R. J. Schassburger – " "
M. N. Silverman – " "
B. K. Thatcher – " "

A-SW-002170

ATTACHMENT A

Response to EPA: Hestmark letter 8HWM-FF received 10/25/93

1. To determine the appropriate background and operable unit populations for comparison, we understand that some matching of the two populations is done by geologists and chemists. Data for an analyte in a non-background area are grouped according to a combination of background classes which represent independent background populations. A table that cross references the operable unit populations and the background populations will be provided.

> **Concur.** The strawman has been changed to require tables that cross-reference OU media to background media.

2. A more explicit statement of the null hypothesis that is being tested will be included. In addition, a fixed p value of 0.05 will be used for each of the inferential statistical tests as written in the strawman proposal. There was some inconsistency in what was written in the proposal and what was stated in the meeting regarding the p value. A fixed value of 0.05 is what we will accept.

> **Concur.** The strawman states that p values must be less than or equal to 0.05 to demonstrate a significant difference from background. Footnote 3 on page 5 of the strawman, which was not clear on this point, has been deleted.

3. All references to comparison of background and operable unit populations for organics will be removed. Background comparisons apply to inorganics and radionuclides only.

> **Do not concur.** Although background comparisons for organics are not commonly used, there are instances when it may be applicable, in which wide-ranging organic contamination is due to non-site-specific anthropogenic sources. We want to retain the option of performing background comparisons for these organics, when geochemists or geologists determine that it is applicable to do so. In these instances, we will retain the burden of proof, and the applicability of the comparison will be subject to EPA and CDH approval.
>
> The strawman has been rewritten to state that background comparisons for organics will be done on a limited, case-by-case basis, subject to EPA and CDH approval.

4. The use of professional judgement in interpreting the results of the graphical displays and statistical analyses will be limited to consideration of spatial distribution, temporal distribution, and pattern recognition concepts. The strawman proposal included five additional criteria. These will be deleted in the final implementation document.

> **Concur.** The five criteria (intermedia interactions and geochemical processes, not an expected contaminant, blank data, regional background range, and influence of field activities) have been deleted.

5. The non-background population is defined as the entire operable unit remedial investigation set. The data aggregation for the purpose of background comparison will be done within the area defined by the operable unit boundaries.

Concur. Analysis will be done on an OU-wide basis.

6. The attached flowchart, "Background Comparison Methodology", distributed at the meeting will be clarified. It is EPA's understanding that all the data sets will undergo the hot measurement test and the battery of inferential statistical tests (Gehan, Quantile, Slippage, and T-Test) provided the data satisfies the conditions stated in the strawman and on the flowchart. If any one of these tests, including the hot measurement test, shows significance, the analyte will be further considered, using professional judgement, as a contaminant of concern. The flowchart would benefit from the addition of decision blocks after each test indicating the next step if significance is demonstrated or not.

Clarification. The chart "Background Comparison Methodology" attached to EPA's memo is not the same as that distributed at the September 29, 1993 meeting and contained within the strawman proposal. The difference is that nonparametric ANOVA tests are given as options to the Gehan test in the chart within the strawman proposal. Because the Gehan method is not standard and will therefore incur practical liabilities (e.g., the method has not been adequately tested and verified, preliminary usage shows it to require excessive man-hours, and subcontractors will need to be instructed in its use), we want to retain the option of performing standard nonparametric ANOVA testing, using the Wilcoxon or Kruskal-Wallis tests, instead of the Gehan test.

Additional clarification. All tests will be performed, if applicable, regardless of whether other tests demonstrate significance.

Concur with the need to redo the flowchart. This has been done.

6. (continued) We also have some specific questions that need to be addressed in the final document:

a. What happens to data which is carried through the slippage test but does not qualify for the t-test?

Clarification. The data that do not qualify for the t-test will be routed to the "At Least One Test Significant?" block. The flowchart has been revised to show this.

b. What is the basis for the 20% detect value as the criteria for the Quantile test? How does this criteria relate to the criteria for applying this test as stated in Dr. Gilbert's report on page 20?

Clarification. Dr. Gilbert's method proposed looking up tabulated values for n and r parameters. The quantile test could be correctly applied only if the largest n values were all detects. Our statisticians have stated that, typically, this restriction equates to the largest 20% or less of the combined sample sizes being detects, and recommend using a flat 20% to simplify application.

c. What is the basis for the criteria of N>20 value for background and operable unit data?

Clarification. Our statisticians derived this value from application of the Central Limit Theorem for a two sample problem. If both samples have N=20, then there will be 38 total degrees of freedom, which will permit assumptions about the distribution.

7. EG&G's claim that these impacts [of implementing Dr. Gilbert's recommendations] could range from $30,000 up to $120,000 per operable unit is not supported by the information provided. In fact, it appears that there is some evidence that implementation will not negatively impact costs or schedules.

Do not concur. EG&G had provided reasoning behind these estimates in memo 93-RF-11078 (STATISTICAL METHODOLOGY FOR BACKGROUND AND COMPARISONS AT THE ROCKY FLATS PLANT - NMH-463-93) dated September 15, 1993. Because the Gilbert method requires additional work, there will be cost and/or schedule impacts.

In addition to the impacts mentioned above, significant cost impacts are anticipated to result if the Gehan method is used. For OU11, approximately 200 hours were required to perform the Gehan test, when less than 40 hours would have been sufficient to perform standard ANOVA testing.

ATTACHMENT B

Response to CDH letter "DOE Proposed Methodology for Statistical Comparison of Remedial Investigation Data at the Rocky Flats Plant" from G. Baughman to R. Schassburger, dated 10/13/93

1. To minimize any potential future misunderstandings of this agreement, the Division feels that it is critical for the Agencies to develop a formal guidance/policy document institutionalizing the agreement. The Strawman document was written for the purpose of facilitating agreement among the Agencies. However, the end users of this document will be the operable unit managers and sub-contractors preparing and reviewing RFI/RI reports. The majority of these people were not involved in the development of this methodology. It is critical to the future of this agreement that final documentation of this agreement be developed to clearly and concisely guide future end users in the implementation of this methodology. This formal guidance should be completed in parallel with the implementation of the agreement.

> **Concur.** When the strawman has been completed and accepted by all concerned parties, it will then be rewritten as a procedure for statistical comparison of OU data to background.

2. The Division recommends that the title of this document be revised to more accurately reflect its content and intent, that being methodology and guidelines for the comparison of site data to background data. The Division proposes the title, "Guide for Conducting Statistical Comparisons of RFI/RI Data and Background Data at the Rocky Flats Plant," for consideration.

> **Concur.** The CDH's proposed title is an improvement to the current title, and has been adopted.

3. One of the central themes of Dr. Gilbert's recommendations was the need for statisticians to be involved throughout the entire process. However, statistician involvement is not discussed in the methodology. The division requests that the role of the statistician in implementation of this methodology be clarified in this document.

> **Concur.** Statisticians will be employed to verify that the methods used are correct. The strawman has been rewritten to incorporate this.

4. The Division does not believe that references to specific DOE sub-contractors are appropriate in this document. The Division recommends DOE review all references to sub-contractors and, where appropriate, modify the reference to more accurately reflect DOE's role and responsibilities.

> **Concur.** References to DOE subcontractors have been eliminated.

5. This section (Determine Background and OU Target Populations) outlines the steps for matching site and background populations. However, it is unclear exactly how the matching will be implemented. The Division recommends that the rationale for combining media/geology groupings for testing be detailed in this section. For example, any criteria for minimum group size necessary for statistical testing should be specified. The Division further recommends adding a table or diagram depicting the general rationale for grouping data by media and geology.

> **Concur.** The strawman states that the OU will match one or more of several specified background media. In addition, the strawman has been changed to require that a cross-reference be performed between the site and one or more background media.

6. As discussed during the September 29th meeting, and emphasized by Dr. Gilbert, it is critical to statistical hypothesis testing that the hypothesis to be tested is explicitly defined and clearly stated. The Division recommends a statement of the test and null hypotheses, in both "english" (narrative qualitative description) and statistical terms, be added to this section of the methodology so there is no misunderstanding of what is being tested. This statement should also address confidence and power requirements for the tests.

> **Concur.** The strawman has been modified to require statistical and prose statements of the null and alternative hypotheses.

7. The Division does not agree with the blanket statement at the beginning of this discussion, "Under current IAG schedule conditions, analytical data will not be 'validated' when the background comparisons will be made in each draft report." This claim is not substantiated by the schedules submitted by DOE in the approved OU work plans and is in direct contradiction to Dr. Gilbert's Task 5 recommendations. Dr. Gilbert states that, "These data quality evaluations are conducted prior to descriptive graphical analyses and formal statistical tests." In finalizing this methodology, the Division recommends that DOE follow Dr. Gilbert's recommendations for data validation <u>before</u> formal graphical presentation and statistical testing. The need for variance from this approach will be considered by the Division on an OU specific basis.

> **Do not concur.** Under the present system of data validation, the non-validated data are used only for the draft RFI/RI. The final RFI/RI is based solely upon validated data. The lag time between receiving data from the laboratory, and validated data from the independent subcontractor can exceed one month. Waiting for 100% validation may impact schedules, but will probably not change the results in the final RFI/RI. The potential impacts of using non-validated data at each OU will be discussed on a case-by-case basis.

8. The Division recommends DOE add a discussion of detection limits to this section of the methodology. In the past there has been confusion as to what detection limits are being reported and used (instrument detection limits vs contract limits vs reporting limits). Part of this confusion may be because detection limits have not been formal discussed. This section

should state what detection limits are to be used in statistical testing and how they are determined from the RFEDS data set.

Concur. The strawman addresses detection limits, and it specifies how determinations are made on how to handle non-detects.

9. The Division recommends that this section (Preliminary Exploratory Data Appraisal) be moved to the Data Presentation section.

Clarification. We have determined that this section is not necessary, and its steps are generally redundant with the Data Presentation sections, and so we have deleted this section.

10. The Division interprets this section as describing the informal data analysis conducted during RFI/RI preparation and not normally included in the formal RFI/RI report. The Division recommends adding language to indicate that this informal data analysis will be made available and reviewed with the regulators in evaluating the appropriateness of the scope of the formal RFI/RI proposal.

Clarification. We have determined that this section is not necessary, and its steps are generally redundant with the Data Presentation sections, and so we have deleted this section.

11. The Division does not agree with DOE's recommendations that box plots are applicable only when there are no non-detects. The problem of estimating percentiles for data sets with multiple non-detects was not resolved by Dr. Gilbert. The Division recommends that when a reasonably small percentage of non-detects are present, percentiles be estimated using Maximum Likelihood Estimation (MLE) techniques in constructing box plots.

Concur. We will provide box plots unless the percentage of non-detects exceeds 50%. The 50% figure is chosen for consistency with the 1993 Background Geochemical Characterization Report (September 30, 1993).

12. The Division does not agree with DOE's suggestion that histograms are not useful for small or highly censored data sets, such as inorganics. As stated by Dr. Gilbert, such histograms are not likely to be useful in visually assessing whether the data sets are better modeled by a normal or lognormal distribution. However, they may still be useful to visually compare the spread, central tendency, and skewness of the two data sets to look for differences that may be important.

Concur. We will provide histograms unless the percentage of non-detects exceeds 50%. Bars in the histogram will be shaded to indicate the percentage of detects and non-detects within each bar interval.

13. The Division recommends that a discussion be added to this section of the methodology to address what to do when a UTL 99/99 can not be reasonably estimated or is unknown (ie

small or highly censored background data set).

Concur. We have modified the strawman to state that professional judgement and use of geochemical standards will be used. The result will be a geochemical interpretation of data, subject to agency review and approval.

14. The reference in Footnote 2 to OU 1 is not appropriate and should be removed. The inferential tests conducted at OU 1 were the result of a compromise agreement, are not precedent setting for other OUs and are not the tests being proposed in this document. However, as stated in this note, limited professional judgement as presented later in this document may be applicable.

Concur. This footnote has been deleted.

15. This discussion (Footnote 3) should be moved to the DQOs or statistical test definition section of the document.

Clarification. This footnote has been deleted. We intend to use a p value of 0.05, and the footnote made that intent unclear.

16. The Division does not agree with the limitations DOE has placed upon the Slippage Test. The slippage test can be applied to data sets when the largest background point is a non-detect. If the largest background data point is a non-detect then logic must be applied to determine if the slippage test is applicable, but the test should not be categorically eliminated.

Concur. We have rewritten the strawman to state that, if the largest background data point is a non-detect, we will apply judgement to investigate whether or not the slippage test is applicable.

17. The Division recommends limiting the use of professional judgement to the first three criteria; spatial distribution, temporal distribution, and pattern recognition. In addition, it is recommended that the introduction to this section include acknowledgement that in applying professional judgement, the "burden of proof" lies solely on DOE. Professional judgement will only be considered by the Division on a limited basis where well documented and defensible evidence is presented.

Concur. We have eliminated the last five criteria from the strawman, and acknowledged that we will bear the burden of proof.

18. To make the process more efficient the task of eliminating non-detected analytes should be completed prior to data presentation. The flow chart should be modified to reflect this change.

Concur. We have changed the flowchart. CDH's comment improved the process.

19. This flow chart is confusing and difficult to follow due to the many multiple and

undefined branches. To minimize the potential for misunderstanding this chart must either be clarified or deleted.

> **Concur.** The flowchart is too important to delete. It has been clarified. Lines denoting the flow of information have been deleted, keeping only the lines denoting flow of control, in accordance with common flowcharting techniques. Decision blocks have been transformed into diamond shapes. Alternative "No" paths have been added for the blocks labeled "No Non-Detect Present...OU Data Normally Distributed?", and "At Least One Test Significant?" Finally, the block representing the conditions which must be met prior to performing the t-test has been changed to reflect the conditions given in the text.

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The Administrative Record Staff

Guide for Conducting Statistical Comparisons of RFI/RI Data and Background Data At the Rocky Flats Plant

General

This document is intended to provide guidelines for OU-to-background comparisons of data, and to explicitly discuss approaches to the issue of determining OU-specific contamination. The OU-to-background comparison will be applied for inorganics and radionuclides. In addition, the comparison may occasionally be performed for organics on a limited, case-by-case basis, subject to EPA and CDH approval.

It is important to establish a common approach leading to a common list of possible contaminants for each OU. To this end, the Figure GENERAL APPROACH TO DETERMINING "CONTAMINANTS" was developed. In this general technique, a "Tool-Box" approach is employed to arrive at one common list of contaminants for each OU (or subdivision), for all functional aspects of the RFI/RI and CMS/FS.

As indicated, several disciplines such as the Human Health or Ecological Risk Assessors and Regulatory specialists may pare the list of contaminants to "Contaminants of Concern" (COCs) based on factors germane to their application (e.g., toxicity).

The text below follows TASK 4: FLOWCHART FOR COMPARING OU DATA TO BACKGROUND.

Start

Determine Background and OU Target Populations

Appropriate geographical, geological, and temporal data sets will be defined for comparison. This is essentially a matching exercise so that Site (OU) data sets are comparable to background sets. Consideration will be given to issues such as:

- Geologic materials
- Hydrostratigraphic unit
- Temporal comparability
- Sample size for statistical tests
- Confidence in geo/hydrologic regime determination

The background data sets will be taken from the current version of the Background Geochemistry Report. The following media have defined backgrounds: groundwater (Rocky Flats Alluvium, valley fill alluvium, colluvium, weathered sandstone, and unweathered Arapahoe/Laramie formation rocks), surface water (Rock Creek and Woman Creek), seeps, stream sediments (Rock Creek and Woman Creek), seep sediments, and soils (Rocky Flats Alluvium, colluvium, surficial, weathered claystone, and weathered Arapahoe, Laramie sandstone). Tables that cross-reference site media to background media will be provided.

Set DQO's

DQOs are established to define data needs for each of the RFI/RI tasks, coordinate that collection activities support those needs, and ensure the quality and quantity of resultant data. Three stages are used in the development of DQOs:

Identify Decision Types:

- Identify and involve data users,
- Evaluate available data,
- Develop a conceptual model of the study site, and
- Specify RFI/RI objectives, and anticipate the decisions necessary to achieve the objectives.

Identify Data Uses and Needs:

- Identify data uses,
- Identify data types,
- Identify data quality needs,
- Identify data quantity needs,
- Evaluate sampling and analysis options, and
- Review data precision, accuracy, representativeness, completeness, and comparability (PARCC).

Design Data Collection Program:

- Assemble data collection components, and
- Develop data collection documentation.

Data Collection and Validation

Under current IAG schedule conditions, analytical data may not be 100% "validated" when the background comparisons are made in each draft report. The potential impacts of using non-validated data will be discussed on a case-by-case basis.

Data Presentation

Several data presentation techniques were identified by Dr. Gilbert as appropriate for different conditions. To perform them all for all compounds in a standard full suite is not necessary when it is clear from a preliminary review that the vast majority of data points for some compounds are entirely or almost entirely non-detects.

Accordingly, we have refined the methodology as follows:

> **Box plots** will be used when the percentage of non-detects is 50% or less.
>
> **Histograms** will also be used when the percentage of non-detects is 50% or less. Bars in the histogram will be shaded to indicate the percentage of detects and non-detects within each bar interval.
>
> **Probability plots, ordered listings**, and other graphics will be used as appropriate.

As indicated by the OU1 process, visual presentation of the data is important. Interpretable graphics will be produced to the extent that they facilitate analysis. In general, graphics will be a central feature of analysis.

BACKGROUND COMPARISON METHODOLOGY TOOL BOX APPROACH

Employing: Bounding-Benchmark Comparison (Hot Measurement), Inferential Statistics, and Professional Judgement

General

The tool-box approach employs a bounding-benchmark comparison, inferential statistics, and professional judgement. This approach was forwarded in the OU1 comment-resolution process, endorsed by Dr. Gilbert, and is widely applied in the hazardous waste industry and environmental business across America. It employs a "weight-of-evidence" framework wherein all three aspects are factored into the determination of what is a Site (OU) contaminant. Statisticians will be used to verify that the methods used are correct.

Bounding Benchmark Comparison "Hot Measurement Test" Component

- o A hot-measurement test will be performed that will compare each analyte concentration to an upper-limit value for that analyte.

- o The upper-limit value will be the value at which there is a 99% confidence that 99% of the background distribution will be below this value ($UTL_{99/99}$). If the $UTL_{99/99}$ cannot be calculated or reasonably estimated, then background values from technical literature and professional judgement will be used. The resulting geochemical interpretation of data will be subject to Agency review and approval.

- o The $UTL_{99/99}$ is required instead of a toxicity-based value because a single list of potential contaminants must be used by many disciplines (Human Health, Ecological, Regulatory, etc.,) to ensure consistency across the RFI/RI and CMS/FS Reports. The subjective nature of what is "hot", as well as toxicity and ARAR considerations, will be dealt with by the specialists who determine COC's specific to their discipline. See the Figure UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT for a comparison of UTL's and Human Health Toxicity-based "Hot-Measurement" values.

- o In addition to ensuring that high concentrations do not get overlooked, the $UTL_{99/99}$ is an important tool for identifying locations of suspected elevated concentration in the nature and extent section.

Background Comparison Using Inferential Statistical Methods

Based on Dr. Gilbert's work, the following inferential statistical tests will be used to compare background data sets to data sets compiled at the Operable Units (OUs). These data sets will be compiled and compared by analyte, and by the correct background data set (i.e., colluvium, alluvium, alluvium + colluvium, surface soils, etc. [See Determine Background and OU Target Populations]).

It should be noted that Dr. Gilbert's recommendations establish a framework that emphasizes using the most appropriate test available. Thus professional judgement will be necessary both in application of inferential tests, as well as their interpretation. Additionally, within the framework of a battery of tests drawn from a "tool box" of methods, it is requested that EPA and CDH remain open to consultation on the use of other tests as appropriate.

The results of all tests (hot-measurement, inferential) will then be evaluated in light of professional judgement. This process is depicted on the figure BACKGROUND COMPARISONS METHODOLOGY.

If hot-measurement or inferential statistical tests show that the concentration of a given analyte in the OU data set is not greater than the concentration in the background data set, and if considerations in the professional-judgement arena do not override, then the analyte is considered not to be a contaminant.

If either the hot measurement test or at least one inferential statistical test shows that the concentration of a given analyte in the OU data set may be greater than the concentration in the background data set, then professional judgement (using temporal and spatial analysis, as well as pattern-recognition concepts) is again applied to see if the analyte concentrations in the two data sets are actually different.

After the hot-measurement test and prior to the use of statistical testing, the issue of non-detects must be dealt with for all tests except the Gehan test, which can be applied with non-detects present. For all other tests, nondetects should be replaced with a value of 0.5 times the applicable detection limit, following EPA guidance (Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance, July 1992), but realizing the performance of simple substitution decreases with an increasing proportion of non-detects.

The handling of non-detects, and the presence of multiple detection limits in the RFEDS data base, requires the use of good professional judgement along with the general guidance offered here. The use of graphical displays of data will assist in the handling of high-value non-detects.

A discussion of detection limits will be given at this point.

Gehan Test or Nonparametric ANOVA Test

- The Gehan test is a nonparametric test and can be used when multiple detection limits are present. The Gehan test will be applied without replacing non-detects. These are the principal favorable attributes of the Gehan test.

- Standard nonparametric ANOVA tests (Wilcoxon Rank Sum and Kruskal-Wallis) are widely used in environmental assessment, and are discussed in EPA guidance (Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance, July 1992). These tests require replacement of non-detect values, either by simple substitution or maximum-likelihood methods.

- For the Gehan or nonparametric ANOVA test, a p-value will be generated and p-values that are equal to or less than 0.05 will normally be considered indicative of a significant difference from background. Statements of the test and null hypotheses will be given, in both statistical and narrative terms.

Quantile Test

- The quantile test is also a nonparametric test and can be considered as a rapid screening test.

- Due to limitations in the quantile test, the test will only be used if the largest 20% of the combined background and site data are detects.

- A p-value will be generated and p-values that are equal to or less than 0.05 will indicate a significant difference from background. Statements of the test and null hypotheses will be given, in both statistical and narrative terms.

Slippage Test

- o The slippage test is a nonparametric test and can be considered as a rapid screening test.
- o Due to limitations in the slippage test, the test will possibly not be used if the largest background value is a non-detect. If the largest background value is a non-detect, then professional judgement will be applied to determine whether or not the slippage test is applicable. For example, if the second largest background value is a detect and is similar in value to the largest background value, it could be used in place of the largest value (although the replacement must be taken into account when interpreting the test results).
- o A p-value will be generated and p-values that are equal to or less than 0.05 will indicate a significant difference from background. Statements of the test and null hypotheses will be given, in both statistical and narrative terms.

T-Test

- o The t-test is a parametric test and is very commonly used when testing the difference between means of two data sets.
- o Due to limitations in the t-test, the test will be applied in cases where both background and OU data are normally or log-normally distributed and contain at least 20 data points, and less than 20% of the background and OU data are classified as non-detects.
- o A p-value will be generated and p-values that are equal to or less than 0.05 will indicate a significant difference from background. Statements of the test and null hypotheses will be given, in both statistical and narrative terms.

Due to their wide use in statistical applications, including regulatory settings, it is possible that ANOVA (parametric and non-parametric) tests may qualify as the most appropriate tests, notwithstanding their limitations with non-detects and multiple detection limits. DOE and its contractor shall confer with EPA and CDH, and seek regulatory assistance prior to the use of these tests, and any other tests deemed applicable, as appropriate. For example, see the attached Figure 1-2, SELECTION OF STATISTICAL METHOD FOR COMPARISON OF BACKGROUND AND NONBACKGROUND POPULATIONS, from the 1993 Background Geochemistry Report.

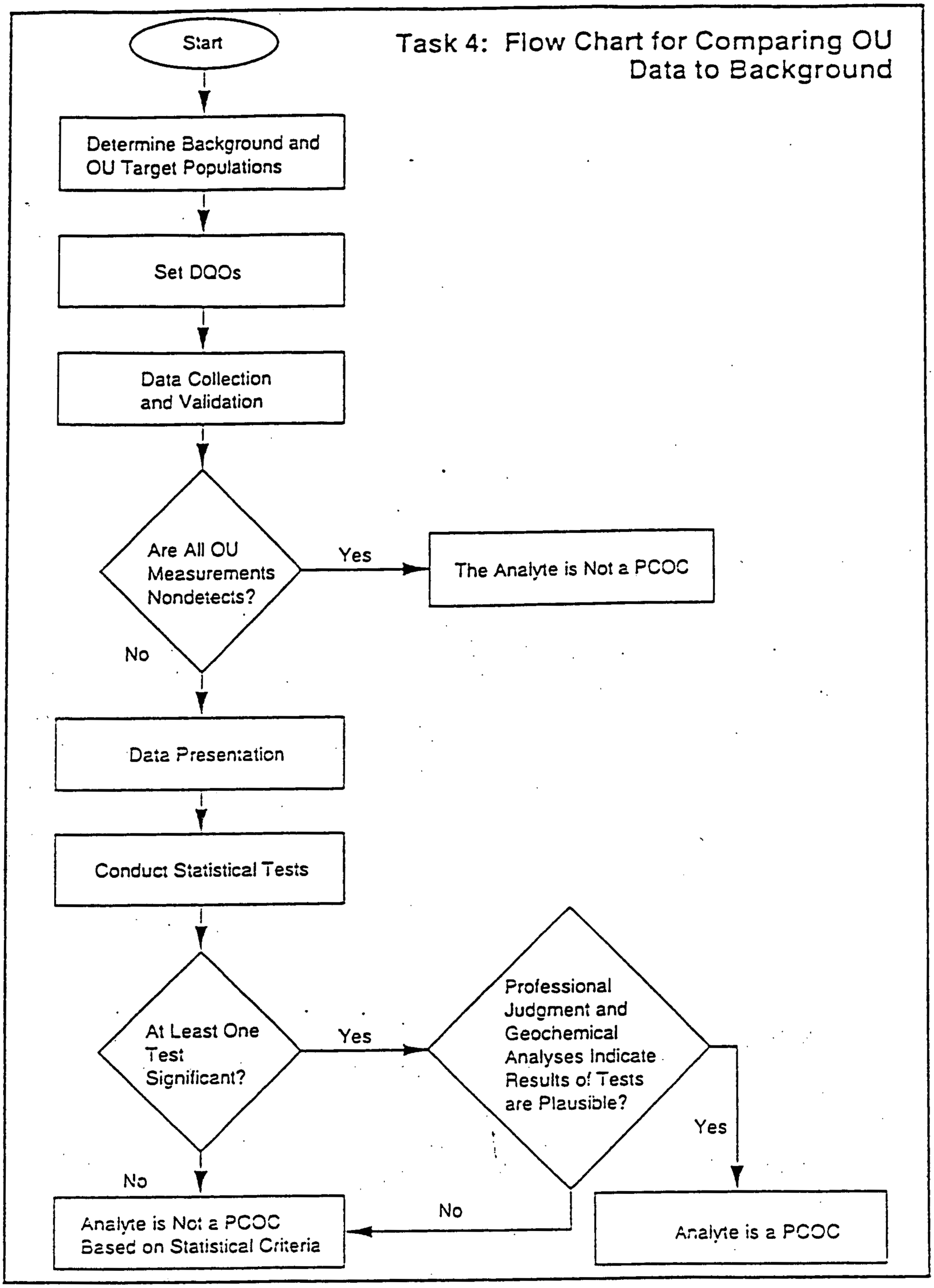
Professional Judgement

The following general guidelines will be used individually and collectively, in conjunction with the above comparison and statistical "tools" to ascertain if a reported analytical detection(s) constitutes contamination at the OU. When professional judgement is applied, documented and defensible evidence will be furnished, and DOE will bear the "burden of proof".

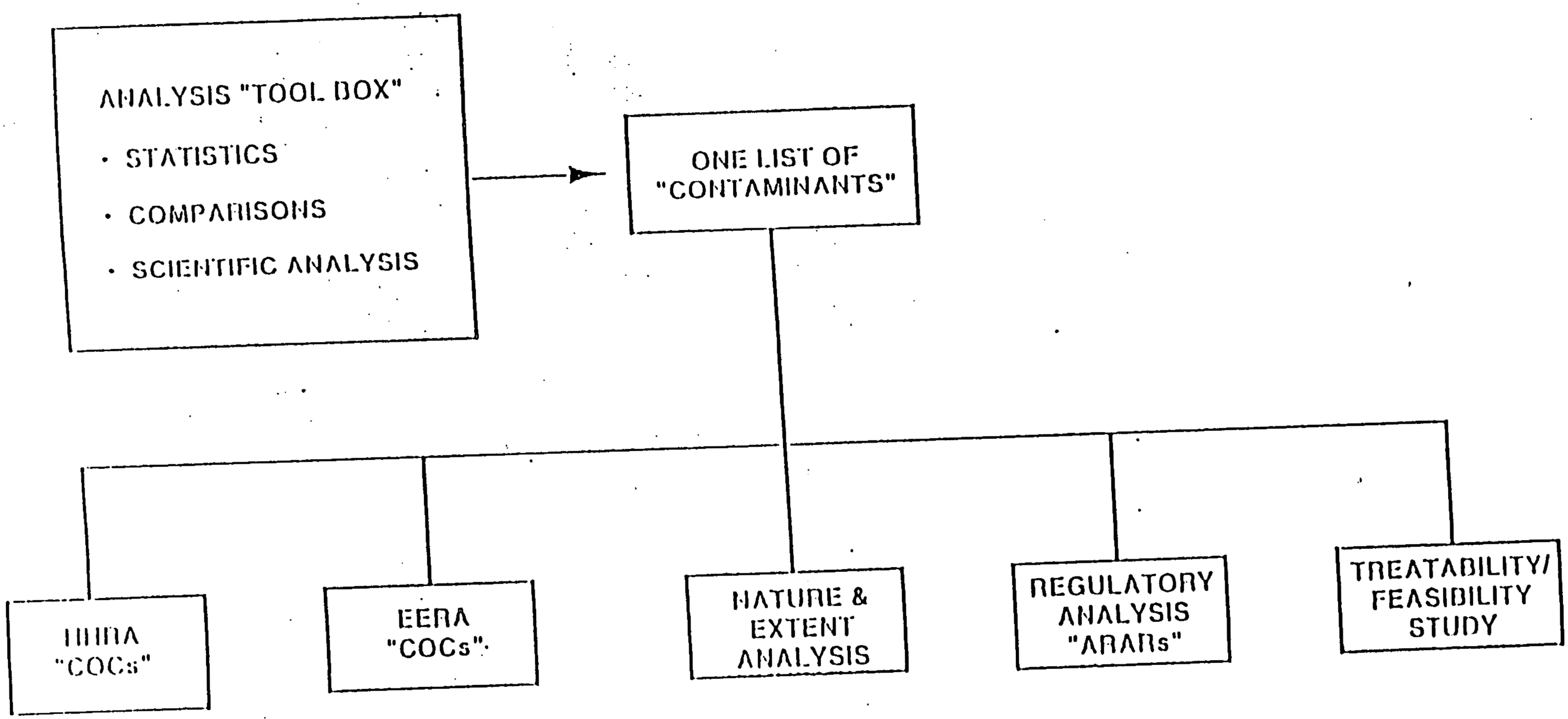
- **Spatial distribution** of analytes above background are or are not indicative of contamination due to waste-related activities at the OU. Spatial plots, interpreted in a source-to-receptor conceptual model, in addition to compound-specific mobility considerations, generally assist in interpretation of inconclusive results.

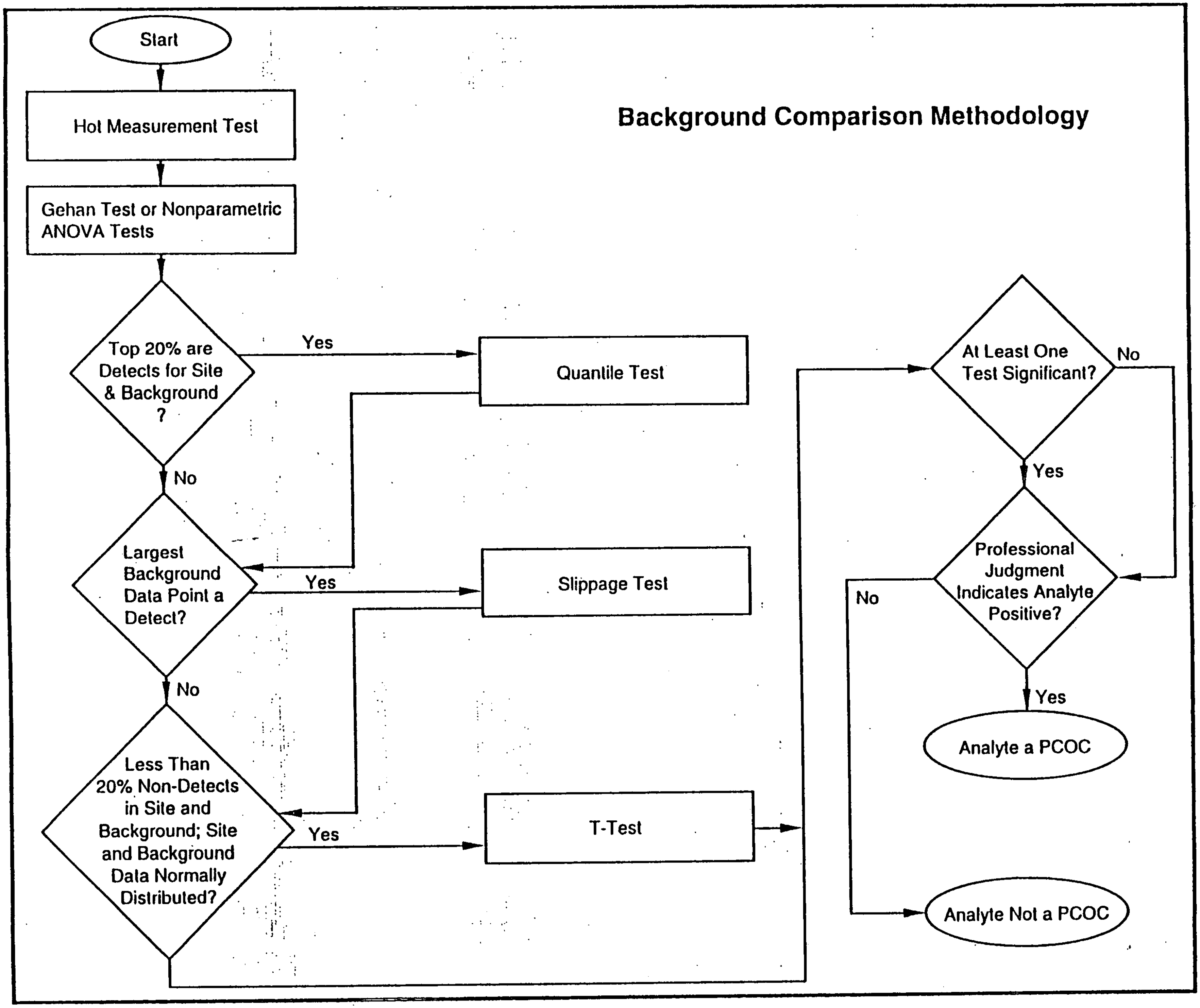
- **Temporal distribution** of analyte concentrations at a station indicates the "high" value(s) is(are) outlier(s). Time-series plots at wells or surface-water locations can generally be used to link apparently insignificant **outlier** reports to seasonal or hydrological phenomena, and vice versa.

- Other associated analytes are determined not to be contaminants in the sample or at the station. Then this may be added to cumulative evidence ("burden of proof") that the analyte in question is not a potential contaminant of concern. **Pattern recognition concepts** are useful in identifying anomalies as well as confirming "fingerprint" associations.


Task 4: Flow Chart for Comparing OU Data to Background
Start
Determine Background and OU Target Populations
Set DQOs
Data Collection and Validation
Are All OU Measurements Nondetects?
Yes
The Analyte is Not a PCOC
No
Data Presentation
Conduct Statistical Tests
At Least One Test Significant?
Yes
Professional Judgment and Geochemical Analyses Indicate Results of Tests are Plausible?
Yes
No
No
Analyte is Not a PCOC Based on Statistical Criteria
Analyte is a PCOC

GENERAL APPROACH TO DETERMINING "CONTAMINANTS"




Background Comparison Methodology
Start
Hot Measurement Test
Gehan Test or Nonparametric ANOVA Tests
Top 20% are Detects for Site & Background ?
Yes
Quantile Test
No
Largest Background Data Point a Detect?
Yes
Slippage Test
No
Less Than 20% Non-Detects in Site and Background; Site and Background Data Normally Distributed?
Yes
T-Test
At Least One Test Significant?
No
Yes
Professional Judgment Indicates Analyte Positive?
No
Yes
Analyte a PCOC
Analyte Not a PCOC

Flow chart from the 1993 Background Report

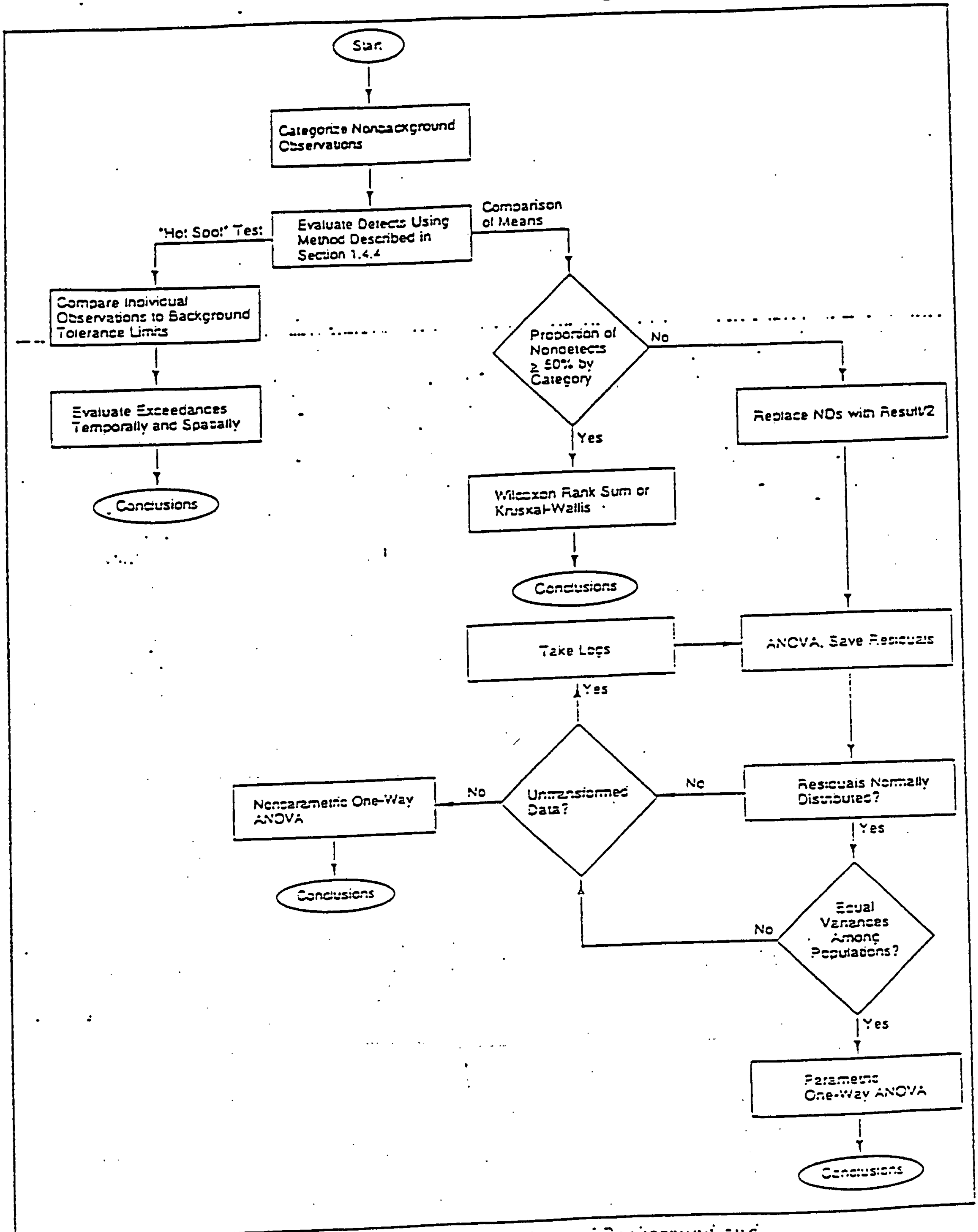


Figure 1-2 Selection of Statistical Method for Comparison of Background and Nonbackground Populations

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add UJV SW & Soh / Bear Creek

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, DISSOLVED METALS

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RSC *	UNITS
ALUMINUM	COL	35	71.43	59.18	49.50	224.21	229.7		UG/L
ANTIMONY	COL	33	33.33	14.84	9.50	46.52	51.25	15,000	UG/L
BARIUM	COL	34	79.41	77.05	39.03	207.99	199	2,500,000	UG/L
CADMIUM	COL	34	23.53	1.97	1.67	7.57	251,782	37,000	UG/L
CALCIUM	COL	35	100.00	96,314.29	34,255.90	210,868.89			UG/L
CHROMIUM	COL	32	15.12	5.87	5.53	25.03		180,000	UG/L
COPPER	COL	33	36.36	5.08	4.20	19.27			UG/L
IRON	COL	34	61.76	46.38	79.70	313.70	265.9		UG/L
LITHIUM	COL	34	88.24	122.77	84.33	406.30	2,618		UG/L
MAGNESIUM	COL	34	100.00	20,479.41	10,610.71	56,070.91	78,665		UG/L
MANGANESE	COL	35	74.29	32.10	38.69	161.12	747.01	5,100,000	UG/L
MOLYBDENUM	COL	33	42.42	19.35	32.15	127.87	60.68	180,000	UG/L
POTASSIUM	COL	33	84.85	2,066.36	1,903.58	8,512.03	17,187		UG/L
SELENIUM	COL	32	62.50	17.40	42.89	163.12	157.56	180,000	UG/L
SILVER	COL	31	25.81	3.22	2.81	12.84		180,000	UG/L
SODIUM	COL	35	100.00	98,454.29	64,522.31	313,594.25	584,414		UG/L
STRONTIUM	COL	34	97.06	701.88	374.80	1,959.08	5,421.7	22,000,000	UG/L
TIN	COL	31	41.94	44.01	62.59	258.16		22,000,000	UG/L
VANADIUM	COL	32	65.62	8.17	7.85	34.84	15.94	250,000	UG/L
ZINC	COL	35	74.29	11.30	10.64	46.78	50.22	11,000,000	UG/L
ALUMINUM	RFA	104	75.00	68.23	125.93	381.64	223.7		UG/L
ANTIMONY	RFA	112	45.56	18.37	12.98	48.61	51.25	15,000	UG/L
BARIUM	RFA	114	53.33	72.22	24.50	123.39		2,500,000	UG/L
CADMIUM	RFA	107	22.43	1.56	1.10	4.29		37,000	UG/L
CALCIUM	RFA	113	100.00	37,555.53	15,707.96	81,245.03			UG/L
CHROMIUM	RFA	113	41.59	4.56	3.33	12.53		180,000	UG/L
COPPER	RFA	112	43.75	4.79	4.13	14.40			UG/L
IRON	RFA	113	75.39	70.28	157.23	436.82	265.9		UG/L
LEAD	RFA	111	24.32	1.40	2.01	5.41			UG/L
LITHIUM	RFA	109	68.81	12.58	17.36	53.12	12.48		UG/L
MAGNESIUM	RFA	112	91.96	4,256.21	1,355.27	7,456.60			UG/L
MANGANESE	RFA	114	52.63	6.17	15.04	41.21		5,100,000	UG/L
MOLYBDENUM	RFA	106	35.85	15.37	34.13	98.85	60.63	180,000	UG/L
NICKEL	RFA	106	36.79	7.66	7.55	25.49			UG/L
POTASSIUM	RFA	110	75.09	925.94	725.81	2,570.48			UG/L
SILVER	RFA	105	28.57	2.73	1.83	7.11		180,000	UG/L
SODIUM	RFA	112	98.21	7,502.21	1,740.42	11,657.40	40,691		UG/L
STRONTIUM	RFA	112	86.61	122.73	81.05	344.89		22,000,000	UG/L
THALLIUM	RFA	92	21.74	1.58	1.64	5.50			UG/L
TIN	RFA	100	41.00	28.72	34.02	108.98	57.59	22,000,000	UG/L
VANADIUM	RFA	111	62.16	8.36	9.95	31.54	15.54	250,000	UG/L
ZINC	RFA	113	79.65	15.69	19.83	61.88	50.22	11,000,000	UG/L

* Example RSCs for illustration of the typical range of a 10E+3 RSC.

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UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, DISSOLVED METALS (CONT)

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE, N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC *	UNITS
ALUMINUM	VFA	74	82.43	52.02	38.51	169.11	229.7		UG/L
ANTIMONY	VFA	69	52.17	16.63	8.82	43.47	51.25	15,000	UG/L
BARIUM	VFA	74	86.49	98.78	35.33	206.21	214.2	2,500,000	UG/L
CADMIUM	VFA	67	22.39	1.71	1.14	5.18		37,000	UG/L
CALCIUM	VFA	74	100.00	61,597.57	30,967.01	155,768.65	156,795		UG/L
CESIUM	VFA	62	27.42	256.67	415.61	1,530.54			UG/L
CHROMIUM	VFA	72	30.56	4.27	3.40	14.62		180,000	UG/L
COBALT	VFA	65	24.62	5.53	8.12	30.63			UG/L
COPPER	VFA	71	38.03	5.04	4.67	19.23			UG/L
IRON	VFA	74	82.43	47.94	50.27	201.11	255.9		UG/L
LEAD	VFA	74	25.68	1.16	1.34	5.24			UG/L
LITHIUM	VFA	73	78.08	22.36	22.93	92.09	145.99		UG/L
MAGNESIUM	VFA	73	97.26	12,570.14	6,554.47	32,502.27	84,598.9		UG/L
MANGANESE	VFA	73	71.23	57.72	97.91	355.47	2791.6	5,100,000	UG/L
MOLYBDENUM	VFA	70	34.29	16.44	31.55	112.37	60.68	180,000	UG/L
NICKEL	VFA	70	32.57	6.37	6.36	25.72	20.69	730,000	UG/L
PHOSPHORUS	VFA	4	100.00	178.75	31.25	572.25			UG/L
POTASSIUM	VFA	75	84.00	1,455.52	745.03	3,721.17	5,390.8		UG/L
SELENIUM	VFA	66	34.85	3.56	10.30	35.30		180,000	UG/L
SILVER	VFA	68	29.41	2.81	2.21	9.53		180,000	UG/L
SODIUM	VFA	74	100.00	33,841.22	16,286.12	83,367.31	148,389		UG/L
STRONTIUM	VFA	72	97.22	376.61	205.32	1,000.97	2,525	22,000,000	UG/L
THALLIUM	VFA	63	25.57	1.50	1.55	6.32			UG/L
TIN	VFA	72	45.83	27.55	28.07	112.90	57.89	22,000,000	UG/L
VANADIUM	VFA	72	70.83	7.03	7.22	28.58	15.94	250,000	UG/L
ZINC	VFA	74	52.43	13.10	16.73	62.99	50.22	11,000,000	UG/L
ALUMINUM	WCS	33	81.82	49.28	28.70	145.14	229.7		UG/L
ANTIMONY	WCS	33	51.52	17.84	9.68	50.52	51.25	15,000	UG/L
BARIUM	WCS	34	82.35	93.57	42.28	225.28	217.8	2,500,000	UG/L
CALCIUM	WCS	34	100.00	58,676.47	28,771.24	148,675.25	216,219		UG/L
CESIUM	WCS	27	25.93	174.03	195.58	665.25			UG/L
CHROMIUM	WCS	33	36.36	5.04	3.42	16.57		180,000	UG/L
COPPER	WCS	32	28.12	5.68	5.17	22.25			UG/L
IRON	WCS	34	76.47	37.53	43.56	182.75	255.9		UG/L
LEAD	WCS	33	27.27	1.57	3.84	14.53			UG/L
LITHIUM	WCS	34	76.47	38.22	55.05	222.88	157.23		UG/L
MAGNESIUM	WCS	34	100.00	12,960.29	8,069.68	40,025.36	66,256		UG/L
MANGANESE	WCS	33	51.52	29.19	91.63	335.48	132.8	5,100,000	UG/L
MOLYBDENUM	WCS	32	43.75	27.83	40.01	163.76	60.58	180,000	UG/L
NICKEL	WCS	31	22.58	6.99	7.49	32.63		730,000	UG/L
POTASSIUM	WCS	34	82.35	1,533.82	878.64	4,881.04	7,240		UG/L
SELENIUM	WCS	30	60.00	10.04	16.91	68.30	229.23	180,000	UG/L
SILVER	WCS	31	29.03	2.91	1.57	9.66		180,000	UG/L
SODIUM	WCS	33	100.00	40,293.94	55,180.62	226,549.22	197,886		UG/L
STRONTIUM	WCS	34	100.00	461.79	380.66	1,735.31	2,242	22,000,000	UG/L
THALLIUM	WCS	28	21.43	1.79	1.30	8.03			UG/L
TIN	WCS	32	43.75	29.52	32.07	138.87	57.89	22,000,000	UG/L
VANADIUM	WCS	34	58.82	8.11	8.41	36.30	15.94	250,000	UG/L
ZINC	WCS	34	55.29	12.34	19.41	78.43	50.22	11,000,000	UG/L

* Example RBCs for illustration of the typical range of a 10E+3 RBC.

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, TOTAL METALS

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC *	UNITS
ALUMINUM	COL	19	100.00	745.11	789.02	3,816.22	46,052		UG/L
ANTIMONY	COL	20	30.00	17.74	9.52	54.22		15,000	UG/L
ARSENIC	COL	20	40.00	1.93	1.65	8.24		49	UG/L
BARIUM	COL	20	85.00	50.87	66.40	345.29	602.5	2,500,000	UG/L
CADMIUM	COL	20	25.00	1.97	1.74	8.64		37,000	UG/L
CALCIUM	COL	20	100.00	99,540.00	37,654.79	243,816.53	354,200		UG/L
CHROMIUM	COL	18	22.22	4.59	4.36	21.88	453.9	180,000	UG/L
COPPER	COL	20	65.00	9.29	11.81	54.54			UG/L
IRON	COL	19	100.00	665.11	679.22	3,308.92	63,512		UG/L
LEAD	COL	18	38.89	2.28	4.27	19.18	25.28		UG/L
LITHIUM	COL	20	85.00	117.94	86.49	449.25	15,762		UG/L
MAGNESIUM	COL	20	100.00	21,220.00	11,477.51	65,296.75	115,185		UG/L
MANGANESE	COL	20	55.00	57.46	125.29	541.73	1081	5,100,000	UG/L
MOLYBDENUM	COL	20	40.00	22.88	35.19	174.05		180,000	UG/L
NICKEL	COL	18	33.33	7.25	6.31	32.25		730,000	UG/L
POTASSIUM	COL	20	75.00	2,013.25	1,853.58	9,258.62	8,250		UG/L
SELENIUM	COL	18	66.67	15.04	47.11	201.61		180,000	UG/L
SILICON	COL	12	100.00	8,600.75	2,462.31	20,008.64	22,845		UG/L
SODIUM	COL	20	100.00	101,010.00	68,738.74	364,366.48	2,406,648		UG/L
STRONTIUM	COL	20	100.00	705.85	379.49	2,159.90	4,001.5	22,000,000	UG/L
THALLIUM	COL	20	35.00	1.58	1.76	8.43			UG/L
TIN	COL	20	40.00	25.25	34.62	167.99		22,000,000	UG/L
VANADIUM	COL	20	75.00	18.82	27.37	121.70	146.8	260,000	UG/L
ZINC	COL	20	55.00	31.55	26.14	170.01	711	11,000,000	UG/L
ALUMINUM	RFA	66	93.94	3,544.45	5,057.31	19,222.71	46,052		UG/L
ANTIMONY	RFA	63	42.86	21.40	15.61	66.88		15,000	UG/L
ARSENIC	RFA	61	27.87	2.07	1.76	7.43		49	UG/L
BARIUM	RFA	66	78.79	96.13	36.75	207.92	602.5	2,500,000	UG/L
CALCIUM	RFA	67	100.00	38,650.30	17,554.04	92,258.54	97,251		UG/L
CESIUM	RFA	65	23.08	150.64	222.63	766.84			UG/L
CHROMIUM	RFA	64	56.25	8.21	7.49	30.99	453.9	180,000	UG/L
COBALT	RFA	66	21.21	8.46	10.20	39.78			UG/L
COPPER	RFA	66	77.27	12.25	13.56	53.48			UG/L
IRON	RFA	66	98.48	4,252.08	5,960.89	22,359.15	63,512		UG/L
LEAD	RFA	63	71.43	3.64	3.55	15.64	25.28		UG/L
LITHIUM	RFA	67	76.12	17.15	19.09	75.19	34.25		UG/L
MAGNESIUM	RFA	67	55.22	5,050.67	2,112.57	11,475.30	11,567		UG/L
MANGANESE	RFA	66	90.91	50.09	112.59	436.73	1081	5,100,000	UG/L
MOLYBDENUM	RFA	68	22.62	24.80	40.28	147.60		180,000	UG/L
NICKEL	RFA	66	40.91	13.25	11.22	47.59		730,000	UG/L
POTASSIUM	RFA	68	76.47	1,578.46	1,190.52	5,198.54	16,191		UG/L
SILICON	RFA	37	100.00	19,033.92	11,446.15	56,777.23	22,845		UG/L
SODIUM	RFA	67	97.01	7,797.16	1,995.28	13,865.12	12,460		UG/L
STRONTIUM	RFA	64	78.12	125.27	23.20	244.47	289.4	22,000,000	UG/L
TIN	RFA	68	22.35	34.01	36.65	145.45		22,000,000	UG/L
VANADIUM	RFA	66	78.79	14.87	11.21	48.57	28.7	260,000	UG/L
ZINC	RFA	67	88.06	40.25	67.22	244.69	711	11,000,000	UG/L

* Example RBCs for illustration of the typical range of a 10E-3 RBC.

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, TOTAL METALS (CONT)

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*REC *	UNITS
ALUMINUM	VFA	43	97.67	2,560.55	3,909.13	14,853.86	46,052		UG/L
ANTIMONY	VFA	41	31.71	16.54	9.86	47.64		15,000	UG/L
ARSENIC	VFA	41	31.71	1.70	1.57	6.65		45	UG/L
BARIUM	VFA	43	83.72	112.77	30.98	210.51	602.5	2,600,000	UG/L
CADMIUM	VFA	43	25.58	1.79	1.78	7.29		37,000	UG/L
CALCIUM	VFA	43	100.00	60,361.72	30,137.33	155,445.78	314,074		UG/L
CESIUM	VFA	40	30.00	142.06	184.65	741.90			UG/L
CHROMIUM	VFA	42	50.00	6.96	6.89	28.69	453.9	180,000	UG/L
COBALT	VFA	43	20.93	6.73	8.52	32.63			UG/L
COPPER	VFA	43	81.40	10.43	12.48	49.80			UG/L
IRON	VFA	43	100.00	2,722.59	4,579.64	17,181.35	63,512		UG/L
LEAD	VFA	40	77.50	3.29	3.25	13.97	28.33		UG/L
LITHIUM	VFA	43	81.40	22.51	18.55	82.29	120.4		UG/L
MAGNESIUM	VFA	43	97.67	12,865.24	6,410.62	33,090.74	56,291		UG/L
MANGANESE	VFA	43	95.35	92.38	104.18	421.07	1,081	5,100,000	UG/L
MERCURY	VFA	43	23.25	0.12	0.04	0.25		11,000	UG/L
MOLYBDENUM	VFA	43	27.91	18.90	36.25	133.29		180,000	UG/L
NICKEL	VFA	43	44.19	8.41	7.05	30.65		730,000	UG/L
POTASSIUM	VFA	43	81.40	1,785.13	912.58	4,667.48	8,250		UG/L
SELENIUM	VFA	42	42.86	3.42	7.57	25.55		180,000	UG/L
SILICON	VFA	23	100.00	15,231.46	11,777.33	59,186.61	32,945		UG/L
SODIUM	VFA	43	100.00	32,929.50	16,184.58	83,992.25	135,509		UG/L
STRONTIUM	VFA	43	95.35	374.14	206.52	1,025.57	2,051	22,000,000	UG/L
THALLIUM	VFA	43	27.91	1.47	1.59	6.49			UG/L
TIN	VFA	42	38.10	31.89	32.57	134.65		22,000,000	UG/L
VANADIUM	VFA	43	79.07	12.20	10.56	45.52	55.5	250,000	UG/L
ZINC	VFA	43	100.00	38.93	28.55	130.03	711	11,000,000	UG/L
ALUMINUM	WCS	19	89.47	1,325.18	2,630.79	11,566.37	46,052		UG/L
ANTIMONY	WCS	17	47.06	19.09	10.53	61.58		15,000	UG/L
BARIUM	WCS	19	84.21	112.17	66.05	370.27	602.5	2,600,000	UG/L
CALCIUM	WCS	19	100.00	53,731.53	13,527.83	106,357.36			UG/L
CESIUM	WCS	20	35.00	188.32	275.25	1,013.07	117,426		UG/L
CHROMIUM	WCS	19	36.84	5.40	4.02	21.06	453	180,000	UG/L
COPPER	WCS	19	57.89	7.15	4.34	24.03			UG/L
IRON	WCS	19	89.47	1,590.19	3,323.54	14,528.42	63,512		UG/L
LEAD	WCS	19	72.68	2.58	2.52	12.89	28.33		UG/L
LITHIUM	WCS	19	73.68	29.12	15.94	91.18	86.88		UG/L
MAGNESIUM	WCS	19	100.00	11,527.89	3,752.95	25,291.71	32,173		UG/L
MANGANESE	WCS	19	68.42	37.44	56.99	259.28	1,081	5,100,000	UG/L
MOLYBDENUM	WCS	19	42.11	33.49	44.45	206.49		180,000	UG/L
POTASSIUM	WCS	19	72.68	1,858.95	500.67	3,807.76	8,250		UG/L
SELENIUM	WCS	18	50.00	9.10	19.03	84.48		180,000	UG/L
SILICON	WCS	10	100.00	10,474.00	5,966.37	40,745.70	32,845		UG/L
SODIUM	WCS	19	100.00	27,557.29	9,531.60	64,655.09	53,658		UG/L
STRONTIUM	WCS	19	100.00	390.47	150.51	976.33	1,163	22,000,000	UG/L
THALLIUM	WCS	18	27.78	1.95	1.96	9.71			UG/L
TIN	WCS	19	31.58	36.28	39.55	193.25		22,000,000	UG/L
VANADIUM	WCS	19	68.42	10.57	9.20	45.39	145.6	250,000	UG/L
ZINC	WCS	19	84.21	25.91	17.93	95.69	711	11,000,000	UG/L

* Example RBCs for illustration of the typical range of a 10E+3 RBC.

GWTM 17

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER TOTAL METALS (CONT)

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC *	UNITS
ALUMINUM	KAR	37	91.89	1,791.87	2,772.43	10,537.17	46,052		UG/L
ANTIMONY	KAR	35	31.43	15.62	10.40	50.28		15,000	UG/L
ARSENIC	KAR	35	54.29	2.76	2.02	9.51		45	UG/L
BARIUM	KAR	36	86.11	112.95	51.97	286.27		2,600,000	UG/L
CALCIUM	KAR	37	100.00	36,352.43	23,831.47	115,130.79	154,031		UG/L
CESIUM	KAR	35	25.71	131.59	175.16	715.62			UG/L
CHROMIUM	KAR	36	33.89	5.25	4.61	20.54		180,000	UG/L
COPPER	KAR	36	61.11	11.99	21.82	84.34			UG/L
IRON	KAR	37	54.59	2,229.92	3,697.44	14,432.11	63,512		UG/L
LEAD	KAR	36	61.11	3.82	4.29	18.06	28.35		UG/L
LITHIUM	KAR	37	86.49	40.69	29.29	137.26	271.8		UG/L
MAGNESIUM	KAR	37	94.59	6,679.46	5,030.81	22,268.40	25,784		UG/L
MANGANESE	KAR	37	86.45	61.67	125.21	474.75	1081	5,100,000	UG/L
MERCURY	KAR	37	27.03	0.13	0.05	0.28		11,000	UG/L
MOLYBDENUM	KAR	36	47.22	18.59	22.45	123.48		180,000	UG/L
NICKEL	KAR	35	34.29	8.70	7.25	32.59		730,000	UG/L
POTASSIUM	KAR	37	89.19	2,846.38	1,725.69	8,536.77	13,625		UG/L
SELENIUM	KAR	36	22.22	1.19	0.63	3.27		180,000	UG/L
SILICON	KAR	20	100.00	9,427.50	6,631.12	34,835.00			UG/L
SODIUM	KAR	37	100.00	129,222.38	134,404.33	582,422.16	1,751,482		UG/L
STRONTIUM	KAR	37	57.03	299.78	312.58	1,430.50	1,842	22,000,000	UG/L
THALLIUM	KAR	36	27.78	1.40	1.50	6.36			UG/L
TIN	KAR	37	29.73	27.46	31.18	130.28		22,000,000	UG/L
VANADIUM	KAR	36	55.44	10.43	11.25	47.75	2,798	250,000	UG/L
ZINC	KAR	35	57.22	52.45	51.31	222.56	711	11,000,000	UG/L

* Example RBCs for illustration of the typical range of a 10E+3 RBC.

GWFM.

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, DISSOLVED METALS (CONT)

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*REC *	UNITS
ALUMINUM	KAR	66	78.79	48.81	44.02	182.67	229.7		UG/L
ANTIMONY	KAR	63	44.44	15.50	9.17	43.37	51.25	15,000	UG/L
ARSENIC	KAR	59	49.15	2.41	1.70	7.77	5.56	49	UG/L
BARIUM	KAR	66	86.36	64.18	21.79	150.44	217.8	2,500,000	UG/L
CADMIUM	KAR	62	22.58	1.76	1.23	5.80		37,000	UG/L
CALCIUM	KAR	67	100.00	34,535.82	22,552.79	106,159.84	206,806		UG/L
CESIUM	KAR	54	29.63	160.68	179.54	728.59			UG/L
CHROMIUM	KAR	65	26.15	3.97	3.15	13.55		180,000	UG/L
COPPER	KAR	65	27.69	4.17	3.83	15.82			UG/L
IRON	KAR	67	79.10	33.67	35.32	141.06	265.9		UG/L
LEAD	KAR	64	20.31	1.80	5.27	17.83			UG/L
LITHIUM	KAR	66	81.82	38.53	27.84	123.21	221.95		UG/L
MAGNESIUM	KAR	67	97.01	6,072.16	4,067.56	18,441.63	25,948		UG/L
MANGANESE	KAR	67	71.64	9.29	7.24	31.31	149.8	5,100,000	UG/L
MOLYBDENUM	KAR	64	53.13	16.86	27.01	99.00	60.68	180,000	UG/L
NICKEL	KAR	65	23.08	5.81	6.25	24.66		730,000	UG/L
PHOSPHORUS	KAR	4	100.00	174.75	85.65	1,225.68			UG/L
POTASSIUM	KAR	67	89.55	2,731.18	1,612.29	7,634.46	14,589		UG/L
SELENIUM	KAR	54	29.63	1.34	1.09	4.78		180,000	UG/L
SILVER	KAR	59	28.81	2.59	2.01	9.03		180,000	UG/L
SODIUM	KAR	67	100.00	142,012.59	125,521.56	554,122.75	912,187		UG/L
STRONTIUM	KAR	66	100.00	383.02	294.27	1,277.90	3,209.8	22,000,000	UG/L
THALLIUM	KAR	58	21.43	1.72	1.57	7.52			UG/L
TIN	KAR	65	40.00	22.97	25.30	100.01		22,000,000	UG/L
VANADIUM	KAR	65	58.92	6.71	7.50	29.21	15.54	250,000	UG/L
ZINC	KAR	67	52.58	10.96	10.29	41.59	50.22	11,000,000	UG/L

* Example RECs for illustration of the typical range of a 10E+3 REC.

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, DISSOLVED RADIONUCLIDES

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	UTL 99 / 99	LAST YEAR'S 95 / 95 UTLs	1000*RBC *	UNITS
CESIUM-137	COL	2	100.00	0.36	0.42	78.73		1,700	pCi/L
GROSS ALPHA	COL	30	100.00	41.31	72.79	312.85	255.23		pCi/L
GROSS BETA	COL	27	100.00	17.51	29.87	122.04	122.20		pCi/L
RADIUM-226	COL	15	100.00	0.21	0.10	0.64	1.88	400	pCi/L
STRONTIUM-89,90	COL	23	100.00	0.25	0.24	1.13	0.57	1,400	pCi/L
TRITIUM	COL	31	100.00	78.12	109.42	450.48	329.84	880,000	pCi/L
URANIUM-233,234	COL	30	100.00	31.82	56.44	226.34	204.43	3,000	pCi/L
URANIUM-235	COL	30	100.00	0.86	1.29	5.63	5.07	3,000	pCi/L
URANIUM-238	COL	24	100.00	25.70	42.13	180.03	143.66	3,000	pCi/L
CESIUM-137	RFA	15	100.00	0.27	0.29	1.48		1,700	pCi/L
GROSS ALPHA	RFA	82	100.00	0.59	0.60	2.02	1.56		pCi/L
GROSS BETA	RFA	76	100.00	1.66	1.52	6.22	4.47		pCi/L
RADIUM-226	RFA	2	100.00	0.17	0.04	7.91		400	pCi/L
RADIUM-228	RFA	2	100.00	2.20	0.42	60.95		480	pCi/L
STRONTIUM-89,90	RFA	81	100.00	0.27	0.23	0.56	0.60	1,400	pCi/L
TRITIUM	RFA	63	100.00	162.03	232.01	641.20	232	880,000	pCi/L
URANIUM-233,234	RFA	78	100.00	0.23	0.21	0.68	0.72	3,000	pCi/L
URANIUM-235	RFA	78	100.00	0.03	0.07	0.23	0.17	3,000	pCi/L
URANIUM-238	RFA	69	100.00	0.14	0.14	0.55	0.48	3,000	pCi/L
CESIUM-137	VFA	17	100.00	0.53	0.71	3.43		1,700	pCi/L
GROSS ALPHA	VFA	60	100.00	2.93	3.17	12.94	68.09		pCi/L
GROSS BETA	VFA	55	100.00	2.20	1.59	8.54	25.77		pCi/L
RADIUM-226	VFA	13	100.00	0.31	0.11	0.51	1.58	400	pCi/L
RADIUM-228	VFA	4	100.00	2.08	0.62	9.75		480	pCi/L
STRONTIUM-89,90	VFA	59	100.00	0.49	0.28	1.52	1.15	1,400	pCi/L
TRITIUM	VFA	42	100.00	115.00	137.54	545.25	392.17	880,000	pCi/L
URANIUM-233,234	VFA	60	100.00	2.05	2.77	10.80	10.47	3,000	pCi/L
URANIUM-235	VFA	60	100.00	0.08	0.12	0.47	0.43	3,000	pCi/L
URANIUM-238	VFA	49	100.00	1.66	2.20	8.92	8.14	3,000	pCi/L
CESIUM-137	WCS	4	100.00	0.32	0.20	2.36		1,700	pCi/L
GROSS ALPHA	WCS	41	100.00	7.70	5.95	25.47	22.31		pCi/L
GROSS BETA	WCS	33	100.00	4.85	3.22	15.41	10.23		pCi/L
RADIUM-226	WCS	6	100.00	0.32	0.06	0.78	1.38	400	pCi/L
STRONTIUM-89,90	WCS	17	100.00	0.24	0.24	1.21	0.91	1,400	pCi/L
TRITIUM	WCS	29	100.00	-23.42	118.54	368.30	274.14	880,000	pCi/L
URANIUM-233,234	WCS	39	100.00	8.59	21.06	77.33	15.18	3,000	pCi/L
URANIUM-235	WCS	39	100.00	0.20	0.51	1.58	0.38	3,000	pCi/L
URANIUM-238	WCS	25	100.00	2.54	2.19	14.17	10.2	3,000	pCi/L
CESIUM-137	KAR	4	100.00	0.22	0.30	3.92		1,700	pCi/L
GROSS ALPHA	KAR	60	100.00	2.13	6.24	22.81	19.55		pCi/L
GROSS BETA	KAR	54	100.00	3.23	2.54	12.19	10.69		pCi/L
RADIUM-226	KAR	2	100.00	1.72	1.78	221.75	1.86	400	pCi/L
STRONTIUM-89,90	KAR	42	100.00	0.47	1.19	4.21	0.91	1,400	pCi/L
TRITIUM	KAR	49	100.00	56.85	125.54	455.77	329.84	880,000	pCi/L
URANIUM-233,234	KAR	57	100.00	1.54	2.55	10.63	9.06	3,000	pCi/L
URANIUM-235	KAR	57	100.00	0.03	0.06	0.23	0.18	3,000	pCi/L
URANIUM-238	KAR	54	100.00	0.77	1.53	5.53	4.76	3,000	pCi/L

* Example RBCs for illustration of the typical range of a 1E-5 RBC.

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, TOTAL RADIONUCLIDES

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE, N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	UTL 99 / 99	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
AMERICIUM-241	COL	25	100.00	0.00	0.00	0.01	0.022	200	pCi/L
CESIUM-137	COL	23	100.00	0.18	0.25	1.49	0.70	1,700	pCi/L
GROSS ALPHA	COL	6	100.00	150.25	142.75	1,157.28	314.5		pCi/L
GROSS BETA	COL	6	100.00	81.55	85.25	706.79	191.6		pCi/L
PLUTONIUM-239,240	COL	25	100.00	0.01	0.01	0.04	0.028	210	pCi/L
STRONTIUM-89,90	COL	7	100.00	0.25	0.11	0.55	0.64	1,400	pCi/L
TRITIUM	COL	17	100.00	201.15	152.29	961.32	537	880,000	pCi/L
URANIUM-233,234	COL	8	100.00	58.74	66.80	446.99	220	3,000	pCi/L
URANIUM-235	COL	8	100.00	2.14	2.39	16.03	10.94	3,000	pCi/L
URANIUM-238	COL	6	100.00	36.04	46.48	376.92	294	3,000	pCi/L
AMERICIUM-241	RFA	82	100.00	0.01	0.01	0.03	0.022	200	pCi/L
CESIUM-137	RFA	75	100.00	0.08	0.23	1.29	0.70	1,700	pCi/L
GROSS ALPHA	RFA	5	100.00	1.89	1.28	13.30	314.5		pCi/L
GROSS BETA	RFA	5	100.00	2.25	1.48	15.45	191.5		pCi/L
PLUTONIUM-238	RFA	7	100.00	0.00	0.00	0.01	0.025		pCi/L
PLUTONIUM-239,240	RFA	85	100.00	0.00	0.00	0.01	0.028	210	pCi/L
STRONTIUM-89,90	RFA	13	100.00	0.11	0.21	1.04	0.084	1,400	pCi/L
TRITIUM	RFA	21	100.00	225.72	307.78	1,256.23	536	880,000	pCi/L
URANIUM-233,234	RFA	12	100.00	0.48	0.45	2.55	1.72	3,000	pCi/L
URANIUM-235	RFA	12	100.00	0.12	0.23	1.05	0.99	3,000	pCi/L
URANIUM-238	RFA	11	100.00	0.40	0.50	2.53	1.55	3,000	pCi/L
AMERICIUM-241	VFA	56	100.00	0.01	0.01	0.05	0.022	200	pCi/L
CESIUM-137	VFA	44	100.00	0.10	0.20	1.05	0.70	1,700	pCi/L
GROSS ALPHA	VFA	7	100.00	3.66	2.06	16.54	314		pCi/L
GROSS BETA	VFA	7	100.00	4.54	2.53	22.56	199		pCi/L
PLUTONIUM-238	VFA	6	100.00	0.01	0.01	0.09	0.025		pCi/L
PLUTONIUM-239,240	VFA	62	100.00	0.01	0.04	0.12	0.025	210	pCi/L
STRONTIUM-89,90	VFA	8	100.00	0.43	0.37	2.56	0.64	1,400	pCi/L
TRITIUM	VFA	27	100.00	142.58	180.22	773.57	536	880,000	pCi/L
URANIUM-233,234	VFA	7	100.00	1.58	1.00	8.01	156.3	3,000	pCi/L
URANIUM-235	VFA	7	100.00	0.10	0.10	0.75	7.65	3,000	pCi/L
URANIUM-238	VFA	2	100.00	1.23	1.20	223.18	91.98	3,000	pCi/L

^ Example RBCs for illustration of the typical range of a 10E-3 RBC.

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UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, TOTAL RADIONUCLIDES (CONT)

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	UTL 99 / 99	LAST YEAR'S 95 / 95 UTLs	1000*RBC *	UNITS
AMERICIUM-241	WCS	20	100.00	0.01	0.01	0.07	0.022	200	pCi/L
CESIUM-137	WCS	14	100.00	0.28	0.36	1.86	0.71	1,700	pCi/L
GROSS ALPHA	WCS	5	100.00	12.65	12.46	124.04	314		pCi/L
GROSS BETA	WCS	5	100.00	8.27	5.11	52.55	191.6		pCi/L
PLUTONIUM-239,240	WCS	21	100.00	0.00	0.00	0.02	0.028	210	pCi/L
RADIUM-226	WCS	4	100.00	0.36	0.15	2.19		400	pCi/L
STRONTIUM-89,90	WCS	4	100.00	0.05	0.26	3.25	0.84	1,400	pCi/L
TRITIUM	WCS	19	100.00	2,128.76	2,537.88	26,918.91	536.7	880,000	pCi/L
URANIUM-233,234	WCS	8	100.00	7.49	6.30	44.13	27.6	3,000	pCi/L
URANIUM-235	WCS	8	100.00	0.28	0.25	1.81	1.34	3,000	pCi/L
URANIUM-238	WCS	3	100.00	5.11	4.56	123.65	91.98	3,000	pCi/L
AMERICIUM-241	KAR	43	100.00	0.01	0.02	0.07	0.022	200	pCi/L
CESIUM-137	KAR	39	100.00	0.00	0.29	0.96	0.48	1,700	pCi/L
GROSS ALPHA	KAR	6	100.00	11.03	16.63	122.08	314		pCi/L
GROSS BETA	KAR	6	100.00	12.01	12.45	110.67	191.6		pCi/L
PLUTONIUM-238	KAR	5	100.00	0.01	0.01	0.14	0.029		pCi/L
PLUTONIUM-239,240	KAR	48	100.00	0.00	0.01	0.02	0.028	210	pCi/L
RADIUM-226	KAR	3	100.00	0.59	0.45	11.30		400	pCi/L
STRONTIUM-89,90	KAR	4	100.00	0.10	0.25	2.34	0.84	1,400	pCi/L
TRITIUM	KAR	18	100.00	62.53	367.23	1,577.10	926	880,000	pCi/L
URANIUM-233,234	KAR	4	100.00	0.77	0.57	7.79	3.68	3,000	pCi/L
URANIUM-235	KAR	4	100.00	0.03	0.02	0.27		3,000	pCi/L
URANIUM-238	KAR	2	100.00	0.25	0.25	48.13	91.98	3,000	pCi/L

* Example RBCs for illustration of the typical range of a 10E+3 RBC.

GMTM

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GEOLOGIC MATERIALS, TOTAL METALS

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE, N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC *	UNITS
ALUMINUM	COL	28	100.00	10,541.43	4,545.85	27,361.88	23,303		MG/KG
ARSENIC	COL	28	85.71	2.57	1.74	9.65	12.1	360	MG/KG
BARIUM	COL	28	100.00	133.20	94.05	462.57	438	9,100,000	MG/KG
BERYLLIUM	COL	28	96.43	5.47	5.47	24.62	18.1	150	MG/KG
CADMIUM	COL	26	57.69	0.86	0.42	2.25		45,000	MG/KG
CALCIUM	COL	28	100.00	9,032.14	6,369.14	31,336.50	22,236		MG/KG
CESIUM	COL	24	75.00	206.24	56.88	412.25			MG/KG
CHROMIUM	COL	28	100.00	13.79	5.86	34.31	42.3	6,800	MG/KG
COBALT	COL	28	25.00	6.11	3.87	19.66			MG/KG
COPPER	COL	28	96.43	14.67	5.48	33.87	22.3		MG/KG
IRON	COL	28	100.00	15,028.07	6,715.26	38,544.51	33,257		MG/KG
LEAD	COL	28	100.00	16.23	4.62	22.40	30.0		MG/KG
LITHIUM	COL	28	28.57	8.52	7.56	34.99	18.5		MG/KG
MAGNESIUM	COL	28	78.57	2,567.22	1,577.50	8,513.05	7,273		MG/KG
MANGANESE	COL	28	100.00	191.87	160.25	752.10	643	10,000,000	MG/KG
MERCURY	COL	27	22.22	0.18	0.20	0.88		80,000	MG/KG
NICKEL	COL	28	92.86	16.97	8.28	45.57	41.9	5,400,000	MG/KG
POTASSIUM	COL	28	35.71	979.61	721.38	3,505.78	3,725		MG/KG
SELENIUM	COL	27	22.22	0.85	0.65	3.15		1,400,000	MG/KG
SILVER	COL	19	42.11	5.85	9.46	42.58		1,400,000	MG/KG
STRONTIUM	COL	28	85.71	55.92	27.04	150.63	131	160,000,000	MG/KG
TIN	COL	23	26.09	87.36	147.51	633.37		150,000,000	MG/KG
VANADIUM	COL	28	100.00	30.31	12.23	73.15	74.3	1,900,000	MG/KG
ZINC	COL	28	100.00	56.13	21.92	132.87	111	81,000,000	MG/KG
ALUMINUM	RFA	62	100.00	12,565.95	13,657.25	55,097.56	46,550		MG/KG
ARSENIC	RFA	62	69.35	4.15	5.70	21.46	12.1	350	MG/KG
BARIUM	RFA	62	83.87	84.46	100.14	388.57	235	9,100,000	MG/KG
BERYLLIUM	RFA	62	87.10	4.65	4.66	18.63	18.1	150	MG/KG
CADMIUM	RFA	46	47.83	0.64	0.48	2.26		45,000	MG/KG
CALCIUM	RFA	62	82.26	6,676.41	19,569.15	67,402.61	16,526		MG/KG
CESIUM	RFA	62	75.81	242.09	337.12	1,257.28			MG/KG
CHROMIUM	RFA	62	100.00	22.08	30.15	113.77	78.9	6,800	MG/KG
COBALT	RFA	62	35.48	8.76	13.16	48.79	76.2		MG/KG
COPPER	RFA	62	87.10	11.68	15.59	59.10	30		MG/KG
IRON	RFA	62	100.00	14,347.10	16,126.79	63,358.57	33,287		MG/KG
LEAD	RFA	62	100.00	9.05	7.07	30.54	24.5		MG/KG
LITHIUM	RFA	62	59.68	14.33	12.95	53.41	18.5		MG/KG
MAGNESIUM	RFA	62	56.06	2,482.38	4,093.78	14,531.58	7,600		MG/KG
MANGANESE	RFA	62	100.00	225.92	417.44	1,505.38	643	10,000,000	MG/KG
MERCURY	RFA	54	42.59	0.29	0.80	2.81		80,000	MG/KG
NICKEL	RFA	59	88.14	23.25	25.45	102.63	72.2	5,400,000	MG/KG
POTASSIUM	RFA	61	27.87	1,545.33	3,026.53	10,780.63	3,725		MG/KG
SILVER	RFA	55	30.91	2.48	5.55	19.99		1,400,000	MG/KG
STRONTIUM	RFA	62	30.65	77.53	87.02	342.55		160,000,000	MG/KG
VANADIUM	RFA	62	56.77	32.03	34.56	128.23	77.1	1,900,000	MG/KG
ZINC	RFA	61	53.44	29.57	61.25	216.23	142	81,000,000	MG/KG

* Example RBCs for illustration of the typical range of a 10E+3 RBC.

GMTM

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GEOLOGIC MATERIALS, TOTAL METALS (CONT)

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
ALUMINUM	WCS	8	100.00	14,181.25	5,022.23	43,375.23	22,303		MG/KG
ARSENIC	WCS	9	77.78	2.94	1.55	11.27	12.1	360	MG/KG
BARIUM	WCS	9	88.89	64.81	26.27	206.40	343	5,100,000	MG/KG
BERYLLIUM	WCS	9	100.00	2.57	1.09	9.45	18.1	150	MG/KG
CADMIUM	WCS	9	22.22	0.63	0.27	2.06		45,000	MG/KG
CALCIUM	WCS	9	66.67	2,212.22	1,256.05	9,520.53	43,000		MG/KG
CESIUM	WCS	9	100.00	214.89	5.99	247.16			MG/KG
CHROMIUM	WCS	9	100.00	20.70	5.53	52.65	32.6	6,800	MG/KG
COPPER	WCS	9	100.00	12.14	5.91	42.99	55.7		MG/KG
IRON	WCS	9	100.00	14,262.22	4,066.80	36,177.70	33,287		MG/KG
LEAD	WCS	9	100.00	6.68	3.15	22.66	69.3		MG/KG
MAGNESIUM	WCS	9	55.56	2,033.89	1,253.56	8,788.12	7,373		MG/KG
MANGANESE	WCS	9	100.00	171.88	99.17	706.30	643	10,000,000	MG/KG
NICKEL	WCS	9	100.00	15.31	6.87	52.21	41.9	80,000	MG/KG
SELENIUM	WCS	9	66.67	1.95	1.25	8.71		1,400,000	MG/KG
SILVER	WCS	9	100.00	24.29	6.54	61.68		1,400,000	MG/KG
TIN	WCS	9	100.00	278.00	65.04	628.52		160,000,000	MG/KG
VANADIUM	WCS	9	100.00	31.42	11.01	90.76	74.3	1,500,000	MG/KG
ZINC	WCS	9	100.00	23.62	8.30	68.34	171	81,000,000	MG/KG
ALUMINUM	KAR	21	100.00	7,482.60	2,581.20	17,608.83	23,111		MG/KG
ARSENIC	KAR	21	66.67	2.72	2.25	16.05	12.1	360	MG/KG
BARIUM	KAR	21	95.24	99.40	55.10	307.51	343	5,100,000	MG/KG
BERYLLIUM	KAR	21	100.00	3.25	3.16	15.29	18.1	150	MG/KG
CADMIUM	KAR	19	57.89	0.53	0.37	2.28		45,000	MG/KG
CALCIUM	KAR	21	100.00	5,477.14	1,531.78	12,295.06	12,740		MG/KG
CESIUM	KAR	16	93.75	222.52	31.25	252.50			MG/KG
CHROMIUM	KAR	21	100.00	8.51	2.56	20.18		6,800	MG/KG
COBALT	KAR	21	23.81	6.74	7.20	23.94			MG/KG
COPPER	KAR	20	100.00	15.76	5.93	28.46	47.9		MG/KG
IRON	KAR	20	100.00	12,963.25	8,753.38	46,502.22	33,287		MG/KG
LEAD	KAR	21	100.00	18.51	6.19	42.29	42.9		MG/KG
LITHIUM	KAR	21	28.57	7.17	8.39	32.84	18.5		MG/KG
MAGNESIUM	KAR	21	66.67	2,053.71	1,273.43	6,636.37	7,273		MG/KG
MANGANESE	KAR	21	100.00	171.90	183.74	865.52	643	10,000,000	MG/KG
MERCURY	KAR	21	33.33	0.23	0.24	1.13		80,000	MG/KG
NICKEL	KAR	19	84.21	18.73	13.29	70.50	72.2	5,400,000	MG/KG
SELENIUM	KAR	19	31.58	0.90	1.01	4.85		1,400,000	MG/KG
SILVER	KAR	16	25.00	3.72	6.22	29.37		1,400,000	MG/KG
STRONTIUM	KAR	21	90.48	69.50	30.95	186.40	314	160,000,000	MG/KG
VANADIUM	KAR	20	90.00	20.70	8.76	54.25	74.3	1,900,000	MG/KG
ZINC	KAR	21	100.00	60.24	19.22	132.52	175	81,000,000	MG/KG

^ Example RBCs for illustration of the typical range of a 10E+3 RBC.

GMTR

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GEOLOGIC MATERIALS, TOTAL RADIONUCLIDES

ANALYTE	GEOLOGY	SAMPLE SIZE, N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	UTL 99 / 99	LAST YEAR'S 95 / 95 UTLs	1000*RBC *	UNITS
CESIUM-137	COL	28	100.00	0.01	0.04	0.17	0.08	27,000	pCi/g
GROSS ALPHA	COL	28	100.00	31.55	8.90	63.10	51.3		pCi/g
GROSS BETA	COL	28	100.00	27.00	3.52	39.22	35.1		pCi/g
PLUTONIUM-239,240	COL	28	100.00	0.01	0.01	0.03	0.017	1,900	pCi/g
RADIUM-226	COL	21	100.00	1.07	0.18	1.77	1.50	1,900	pCi/g
RADIUM-228	COL	21	100.00	1.57	0.29	2.65	2.25	7,500	pCi/g
STRONTIUM-89,90	COL	28	100.00	-0.01	0.36	1.24	0.64	23,000	pCi/g
TRITIUM	COL	28	100.00	82.14	106.16	482.90	303	14,000,000	pCi/g
URANIUM, TOTAL	COL	28	100.00	1.86	0.73	4.41			pCi/g
URANIUM-233,234	COL	28	100.00	1.14	1.58	6.66	1.75	5,200	pCi/g
URANIUM-235	COL	28	100.00	0.04	0.06	0.24	0.17	140	pCi/g
URANIUM-238	COL	28	100.00	0.54	0.34	2.15	1.68	5,800	pCi/g
AMERICIUM-241	RFA	28	100.00	-0.00	0.01	0.02	0.013	1,500	pCi/g
CESIUM-137	RFA	62	100.00	0.01	0.04	0.14	0.08	27,000	pCi/g
GROSS ALPHA	RFA	62	100.00	22.22	8.18	47.21	37.8		pCi/g
GROSS BETA	RFA	62	100.00	24.10	6.75	44.62	36.9		pCi/g
PLUTONIUM-239,240	RFA	62	100.00	0.00	0.01	0.02	0.017	1,900	pCi/g
RADIUM-226	RFA	58	100.00	0.63	0.10	0.96	0.85	1,900	pCi/g
RADIUM-228	RFA	58	100.00	1.34	0.31	2.32	1.97	7,500	pCi/g
STRONTIUM-89,90	RFA	62	100.00	0.03	0.35	1.09	0.64	23,000	pCi/g
TRITIUM	RFA	62	100.00	172.90	122.68	545.96	411	14,000,000	pCi/g
URANIUM, TOTAL	RFA	62	100.00	1.23	0.81	3.76			pCi/g
URANIUM-233,234	RFA	62	100.00	0.64	0.46	2.04	1.49	5,200	pCi/g
URANIUM-235	RFA	62	100.00	0.01	0.03	0.11	0.08	140	pCi/g
URANIUM-238	RFA	62	100.00	0.64	0.38	1.79	1.36	5,800	pCi/g
CESIUM-137	WCS	9	100.00	0.01	0.03	0.19	0.08	27,000	pCi/g
GROSS ALPHA	WCS	9	100.00	23.85	5.88	52.59	55.2		pCi/g
GROSS BETA	WCS	9	100.00	21.89	5.53	51.70	34.6		pCi/g
PLUTONIUM-239,240	WCS	9	100.00	0.01	0.01	0.07	0.017	1,900	pCi/g
RADIUM-226	WCS	4	100.00	0.68	0.15	2.53	1.70	1,900	pCi/g
RADIUM-228	WCS	4	100.00	1.42	0.29	4.98	2.19	7,500	pCi/g
STRONTIUM-89,90	WCS	9	100.00	0.17	0.44	2.55	0.64	23,000	pCi/g
TRITIUM	WCS	9	100.00	174.44	114.47	791.30	449	14,000,000	pCi/g
URANIUM, TOTAL	WCS	9	100.00	1.36	0.21	2.50			pCi/g
URANIUM-233,234	WCS	9	100.00	0.60	0.12	1.25	2.20	5,200	pCi/g
URANIUM-235	WCS	9	100.00	0.02	0.07	0.28	0.44	140	pCi/g
URANIUM-238	WCS	9	100.00	0.73	0.12	1.29	1.94	5,800	pCi/g
CESIUM-137	KAR	21	100.00	0.00	0.00	0.00	0.08	27,000	pCi/g
GROSS ALPHA	KAR	21	100.00	29.58	8.42	61.78	52.1		pCi/g
GROSS BETA	KAR	21	100.00	25.76	3.55	40.29	34.6		pCi/g
PLUTONIUM-239,240	KAR	21	100.00	0.00	0.01	0.03	0.017	1,900	pCi/g
RADIUM-226	KAR	14	100.00	1.09	0.12	1.53	1.40		pCi/g
RADIUM-228	KAR	14	100.00	1.20	0.19	2.14	1.80	1,900	pCi/g
STRONTIUM-89,90	KAR	21	100.00	-0.11	0.36	1.24	0.64	7,500	pCi/g
TRITIUM	KAR	21	100.00	65.55	122.69	523.22	300	14,000,000	pCi/g
URANIUM, TOTAL	KAR	21	100.00	1.56	0.64	4.40			pCi/g
URANIUM-233,234	KAR	21	100.00	0.96	0.39	2.42	1.86	5,200	pCi/g
URANIUM-235	KAR	21	100.00	0.04	0.05	0.25	0.10	140	pCi/g
URANIUM-238	KAR	21	100.00	0.58	0.25	1.32	1.51	5,800	pCi/g

* Example RBCs for illustration of the typical range of a 10E-3 RBC.

SURFICIAL SOILS FROM ROCK CREEK

TOTAL METALS

Analyte	MEAN	STD DEV	N	TOL FACT	99 / 99 UTL	UNITS
Aluminum	12992.9	2251.53	18	3.9604	21909.86	MG/KG
Antimony	10.525	1.724	18	3.9604	17.35	MG/KG
Arsenic	5.817	1.818	18	3.9604	13.02	MG/KG
Barium	195.2	84.63	18	3.9604	530.37	MG/KG
Beryllium	0.983	0.256	18	3.9604	2.00	MG/KG
Cadmium	1.048	0.362	17	4.0367	2.51	MG/KG
Calcium	5068.1	2220.5	18	3.9604	13862.17	MG/KG
Cesium	61.43	61.43	18	3.9604	304.72	MG/KG
Chromium	15.207	2.798	19	3.8924	26.10	MG/KG
Cobalt	7.781	4.305	18	3.9604	24.83	MG/KG
Copper	12.964	3.629	18	3.9604	27.34	MG/KG
Iron	15381.7	3226.62	18	3.9604	28160.41	MG/KG
Lead	37.535	6.024	18	3.9604	61.39	MG/KG
Lithium	10.98	2.273	18	3.9604	19.98	MG/KG
Magnesium	2853.3	1049.95	18	3.9604	7011.52	MG/KG
Manganese	443.67	457.01	18	3.9604	2253.61	MG/KG
Mercury	0.09256	0.0306	18	3.9604	0.21	MG/KG
Molybdenum	3.31997	1.59652	18	3.9604	9.64	MG/KG
Nickel	12.578	3.588	18	3.9604	26.79	MG/KG
Potassium	2977.9	575.47	18	3.9604	5256.99	MG/KG
Selenium	0.4785	0.1468	18	3.9604	1.06	MG/KG
Silicon	780.99	700.452	18	3.9604	3555.06	MG/KG
Silver	1.728	0.693	18	3.9604	4.47	MG/KG
Sodium	175.14	75.031	18	3.9604	472.29	MG/KG
Strontium	35.331	13.811	18	3.9604	90.03	MG/KG
Thallium	0.3773	0.1204	18	3.9604	0.85	MG/KG
Tin	38.346	9.2105	18	3.9604	74.82	MG/KG
Vanadium	31.603	6.049	18	3.9604	55.56	MG/KG
Zinc	55.824	7.795	18	3.9604	86.70	MG/KG

SURFICIAL SOILS FROM ROCK CREEK

TOTAL RADIONUCLIDES

Analyte	MEAN	STD DEV	N	TOL FACT	99 / 99 UTL	UNITS
Americium-241	0.01854	0.0092	15	4.2224	0.06	PCI/G
Cesium-137	1.41	0.4897	12	4.633	3.68	PCI/G
Gross alpha	19.825	4.916	10	5.0737	44.77	PCI/G
Gross beta	32.031	5.699	19	3.8924	54.21	PCI/G
Plutonium-239,240	0.05523	0.02023	18	3.9604	0.14	PCI/G
Radium-226	0.94538	0.12813	10	5.0737	1.60	PCI/G
Radium-228	2.1767	0.5309	10	5.0737	4.87	PCI/G
Strontium-89,90	0.61833	0.29768	9	5.3889	2.22	PCI/G
Uranium-233,234	1.14497	0.15557	16	4.1233	1.79	PCI/G
Uranium-235	0.05263	0.03271	16	4.1233	0.19	PCI/G
Uranium-238	1.18301	0.18799	16	4.1233	1.96	PCI/G

Rads 64% validated
Metals 89% validated

SURFICIAL SOILS FROM ROCK CREEK

TOTAL METALS

Analyte	MEAN	STD DEV	N	TOL FACT	99 / 99 UTL	UNITS
Aluminum	12992.9	2251.53	18	3.9604	21909.86	MG/KG
Antimony	10.525	1.724	18	3.9604	17.35	MG/KG
Arsenic	5.817	1.818	18	3.9604	13.02	MG/KG
Barium	195.2	84.63	18	3.9604	530.37	MG/KG
Beryllium	0.983	0.256	18	3.9604	2.00	MG/KG
Cadmium	1.048	0.362	17	4.0367	2.51	MG/KG
Calcium	5068.1	2220.5	18	3.9604	13862.17	MG/KG
Cesium	61.43	61.43	18	3.9604	304.72	MG/KG
Chromium	15.207	2.798	19	3.8924	26.10	MG/KG
Cobalt	7.781	4.305	18	3.9604	24.83	MG/KG
Copper	12.964	3.629	18	3.9604	27.34	MG/KG
Iron	15381.7	3226.62	18	3.9604	28160.41	MG/KG
Lead	37.535	6.024	18	3.9604	61.39	MG/KG
Lithium	10.98	2.273	18	3.9604	19.98	MG/KG
Magnesium	2853.3	1049.95	18	3.9604	7011.52	MG/KG
Manganese	443.67	457.01	18	3.9604	2253.61	MG/KG
Mercury	0.09256	0.0306	18	3.9604	0.21	MG/KG
Molybdenum	3.31997	1.59652	18	3.9604	9.64	MG/KG
Nickel	12.578	3.588	18	3.9604	26.79	MG/KG
Potassium	2977.9	575.47	18	3.9604	5256.99	MG/KG
Selenium	0.4785	0.1468	18	3.9604	1.06	MG/KG
Silicon	780.99	700.452	18	3.9604	3555.06	MG/KG
Silver	1.728	0.693	18	3.9604	4.47	MG/KG
Sodium	175.14	75.031	18	3.9604	472.29	MG/KG
Strontium	35.331	13.811	18	3.9604	90.03	MG/KG
Thallium	0.3773	0.1204	18	3.9604	0.85	MG/KG
Tin	38.346	9.2105	18	3.9604	74.82	MG/KG
Vanadium	31.603	6.049	18	3.9604	55.56	MG/KG
Zinc	55.824	7.795	18	3.9604	86.70	MG/KG

SURFICIAL SOILS FROM ROCK CREEK

TOTAL RADIONUCLIDES

Analyte	MEAN	STD DEV	N	TOL FACT	99 / 99 UTL	UNITS
Americium-241	0.01854	0.0092	15	4.2224	0.06	PCI/G
Cesium-137	1.41	0.4897	12	4.633	3.68	PCI/G
Gross alpha	19.825	4.916	10	5.0737	44.77	PCI/G
Gross beta	32.031	5.699	19	3.8924	54.21	PCI/G
Plutonium-239,240	0.05523	0.02023	18	3.9604	0.14	PCI/G
Radium-226	0.94538	0.12813	10	5.0737	1.60	PCI/G
Radium-228	2.1767	0.5309	10	5.0737	4.87	PCI/G
Strontium-89,90	0.61833	0.29768	9	5.3889	2.22	PCI/G
Uranium-233,234	1.14497	0.15557	16	4.1233	1.79	PCI/G
Uranium-235	0.05263	0.03271	16	4.1233	0.19	PCI/G
Uranium-238	1.18301	0.18799	16	4.1233	1.96	PCI/G

Where "TOL FACT" is the tolerance factor for the 99/99 UTL, and "STD DEV" is the standard deviation for sample size, N. The 99/99 UTL is calculated as (TOL FACT * STD DEV) + MEAN. Metals are 89-percent validated, and radionuclides are 64-percent validated in this table.

DRINKING WATER STANDARDS (EPA, 1976) AND NON-MANDATORY STANDARDS *

ALUMINUM *	50	UG/L	
ARSENIC	50	UG/L	
BARIUM	1000	UG/L	
CADMIUM	10	UG/L	
CHROMIUM	50	UG/L	
COPPER *	1000	UG/L	
LEAD	50	UG/L	(Lead now has a lower DWS; maybe 5 ppb)
MANGANESE *	50	UG/L	
MERCURY	2	UG/L	
SELENIUM	10	UG/L	
SILVER	50	UG/L	
ZINC *	5000	UG/L	
RADIUM-228	5	pCi/L	
GROSS ALPHA	15	pCi/L	

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